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## RESEARCH MEMORANDUM

INVESTIGATION OF A CANARD MISSILE CONFIGURATION  
(NACA RM-4) IN THE LANGLEY 9-INCH SUPERSONIC  
TUNNEL AT MACH NUMBERS OF 1.62 AND 1.93

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## INVESTIGATION OF A CANARD MISSILE CONFIGURATION

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TUNNEL AT MACH NUMBERS OF 1.62 AND 1.93

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## SUMMARY

An investigation was made in the Langley 9-inch supersonic tunnel of a canard missile configuration designated as the NACA RM-4 configuration. Measurements of lift, drag, and pitching moment were made over an angle-of-attack range of  $-5^{\circ}$  to  $15^{\circ}$  at Mach numbers of 1.62 and 1.93. Breakdown tests were made at a Mach number of 1.62 for several roll angles. For the complete configuration, the deflections of the canard fins and the angle of roll were varied at both Mach numbers. The configuration was tested with canard fins inline and with the canard fins interdigitated  $45^{\circ}$  with respect to the wings. The data are presented without analysis.

## INTRODUCTION

The canard missile configuration designated as the NACA RM-4 research missile has been used extensively as a research vehicle in the transonic and supersonic speed ranges. Flight results obtained by using rocket-powered models have been reported in references 1, 2, and 3. A comparison of wind-tunnel results with free-flight results has been presented in reference 4. This paper presents the results of an investigation of this missile configuration in the Langley 9-inch supersonic tunnel. A few of these results have previously been reported in reference 4.

In the present investigation, measurements of lift, drag, and pitching moment were made over an angle-of-attack range of  $-5^{\circ}$  to  $15^{\circ}$  at Mach numbers of 1.62 and 1.93. To expedite publication, the data are presented without analysis.

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SYMBOLS

B	configuration of body
BC	configuration of body and canard fins
BW	configuration of body and main lifting surfaces
BCW	configuration of body, canard fins, and main lifting surfaces
$C_L$	lift coefficient, $\frac{\text{Lift}}{qA}$
$C_D$	drag coefficient, $\frac{\text{Drag}}{qA}$
$C_m$	pitching-moment coefficient, $\frac{\text{Moment about center of gravity}}{qAd}$
d	maximum body diameter
M	Mach number
$p_o$	stagnation pressure
q	dynamic pressure
R	Reynolds number
A	maximum cross-sectional area of body
$T_o$	stagnation temperature
$\alpha$	angle of attack
$\delta$	canard-fin deflection, positive when trailing edge is down (pitch canard fins) or to left, model viewed from top (yaw canard fins)
$\phi$	angle of roll of model relative to angle-of-attack plane, positive when model, viewed from rear, is rotated clockwise ( $\phi = 0^\circ$ when opposite wing panels are in angle-of-attack plane)



## Subscripts:

e pitch canard fins

r yaw canard fins

## Superscripts:

$\theta, 45$  angle between a plane through opposite canard-fin panels and  
a plane through opposite wing panels

## APPARATUS AND MODELS

The Langley 9-inch supersonic tunnel is a closed-return, direct-drive type in which the pressure and the humidity are controlled. The test Mach number is varied by means of interchangeable nozzle blocks forming test sections approximately 9 inches square. Eleven fine-mesh turbulence-damping screens are provided in the settling chamber ahead of the nozzles. During the tests the amount of water vapor in the tunnel air was kept at sufficiently low values so that the effects of condensation in the supersonic nozzle were negligible.

A drawing of the model giving the pertinent dimensions is shown in figure 1 and a photograph of the model, in figure 2. The sting and sting-windshield arrangement used in these tests is shown in figure 3. At each angle of attack, the model, sting, and sting windshield were translated across the tunnel so that a fixed point on the model could be kept on the center line of the tunnel. Throughout the tests the gap between the rear of the model and the movable windshield was maintained at less than 0.012 inch.

## TESTS

Measurements of lift, drag, and pitching moment were made by means of external self-balancing mechanical scales through an angle-of-attack range of  $-5^\circ$  to  $15^\circ$  for deflections of the canard fins of  $0^\circ$ ,  $3^\circ$ ,  $6^\circ$ ,  $10^\circ$ , and  $15^\circ$  and angles of roll of  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$ , and  $45^\circ$ . The model was tested both with the wings and canard fins inline and with the canard fins interdigitated  $45^\circ$  with respect to the wings. An optical system employing a small mirror mounted in the model was used to measure angles of attack. Measurements were made of the pressure in the sting-shield-and-balance enclosing box (tests have shown this pressure to be equal to the model base pressure) and the drag results were corrected to the condition of base pressure equal to stream static pressure.

The test conditions were as follows:

	M = 1.62	M = 1.93
$T_o$ , $^{\circ}\text{F}$ . . . . .	100	100
$p_o$ , atm . . . . .	1	1
$q$ , lb/sq ft . . . . .	890	790
$R$ , per in. . . . .	$0.348 \times 10^6$	$0.312 \times 10^6$

#### PRECISION OF DATA

The precision of the data has been evaluated by estimating the uncertainties in the balance measurements involved in a given quantity and combining these errors by a method based on the theory of least squares.

The values of the estimated precision are as follows:

Lift coefficient, $C_L$ . . . . .	$\pm 0.0026$
Drag coefficient, $C_D$ . . . . .	$\pm 0.0035$
Pitching-moment coefficient, $C_m$ . . . . .	$\pm 0.033$
Angle of attack, $\alpha$ , deg . . . . .	$\pm 0.01$
Mach number, $M$ . . . . .	$\pm 0.01$

#### PRESENTATION OF DATA

The aerodynamic characteristics at  $M = 1.62$  for the B and BC configurations are shown in figure 4 and the characteristics of the BW configuration, in figure 5. The aerodynamic characteristics at  $M = 1.62$  of the inline BCW configuration ( $BC^0W$ ) are shown in figure 6 for various deflections of the pitch canard fins at a roll angle of  $0^{\circ}$ , and the corresponding results for the interdigitated configuration ( $BC^{45}W$ ) are shown in figure 7. The effect of varying the roll angle upon the characteristics of the  $BC^0W$  and  $BC^{45}W$  configurations for zero deflection of the pitch canard fins is shown in figures 8 and 9, respectively.

The effects of various deflections of the pitch canard fins at  $M = 1.93$  and a roll angle of  $0^\circ$  upon the aerodynamic characteristics of the  $BC^0W$  configuration and the  $BC^{45}W$  configuration are shown in figures 10 and 11, respectively. The effect of varying the angle of roll with fixed deflections of the pitch canard fins at  $M = 1.93$  is shown for the  $BC^0W$  configuration in figure 12 and for the  $BC^{45}W$  configuration in figure 13. The characteristics of the  $BC^0W$  configuration with combined deflections of the pitch and yaw canard fins at roll angles of  $0^\circ$  and  $45^\circ$  are shown in figure 14.

Langley Aeronautical Laboratory,  
National Advisory Committee for Aeronautics,  
Langley Field, Va., May 5, 1954.

#### REFERENCES

1. Zarovsky, Jacob, and Gardiner, Robert A.: Flight Investigation of a Roll-Stabilized Missile Configuration at Varying Angles of Attack at Mach Numbers Between 0.8 and 1.79. NACA RM L50H21, 1951.
2. Niewald, Roy J., and Moul, Martin T.: The Longitudinal Stability, Control Effectiveness, and Control Hinge-Moment Characteristics Obtained From a Flight Investigation of a Canard Missile Configuration at Transonic and Supersonic Speeds. NACA RM L50I27, 1950.
3. Gardiner, Robert A., and Zarovsky, Jacob: Rocket-Powered Flight Test of a Roll-Stabilized Supersonic Missile Configuration. NACA RM L9K01a, 1950.
4. Curfman, Howard J., Jr., and Grigsby, Carl E.: Longitudinal Stability and Control Characteristics of a Canard Missile Configuration for Mach Numbers From 1.1 to 1.93 as Determined From Free-Flight and Wind-Tunnel Investigations. NACA RM L52F06, 1952.

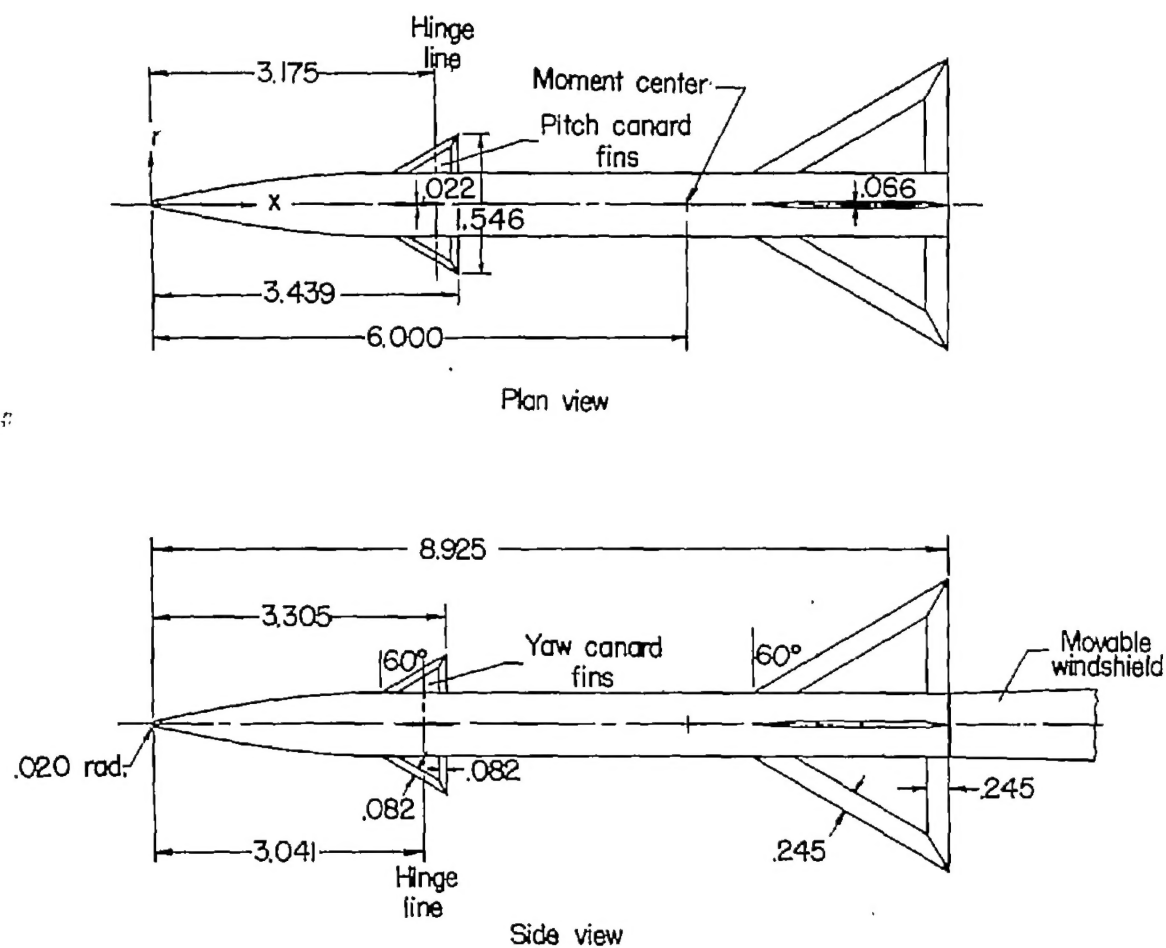


Figure 1.- Model drawing showing pertinent dimensions. All dimensions are in inches.

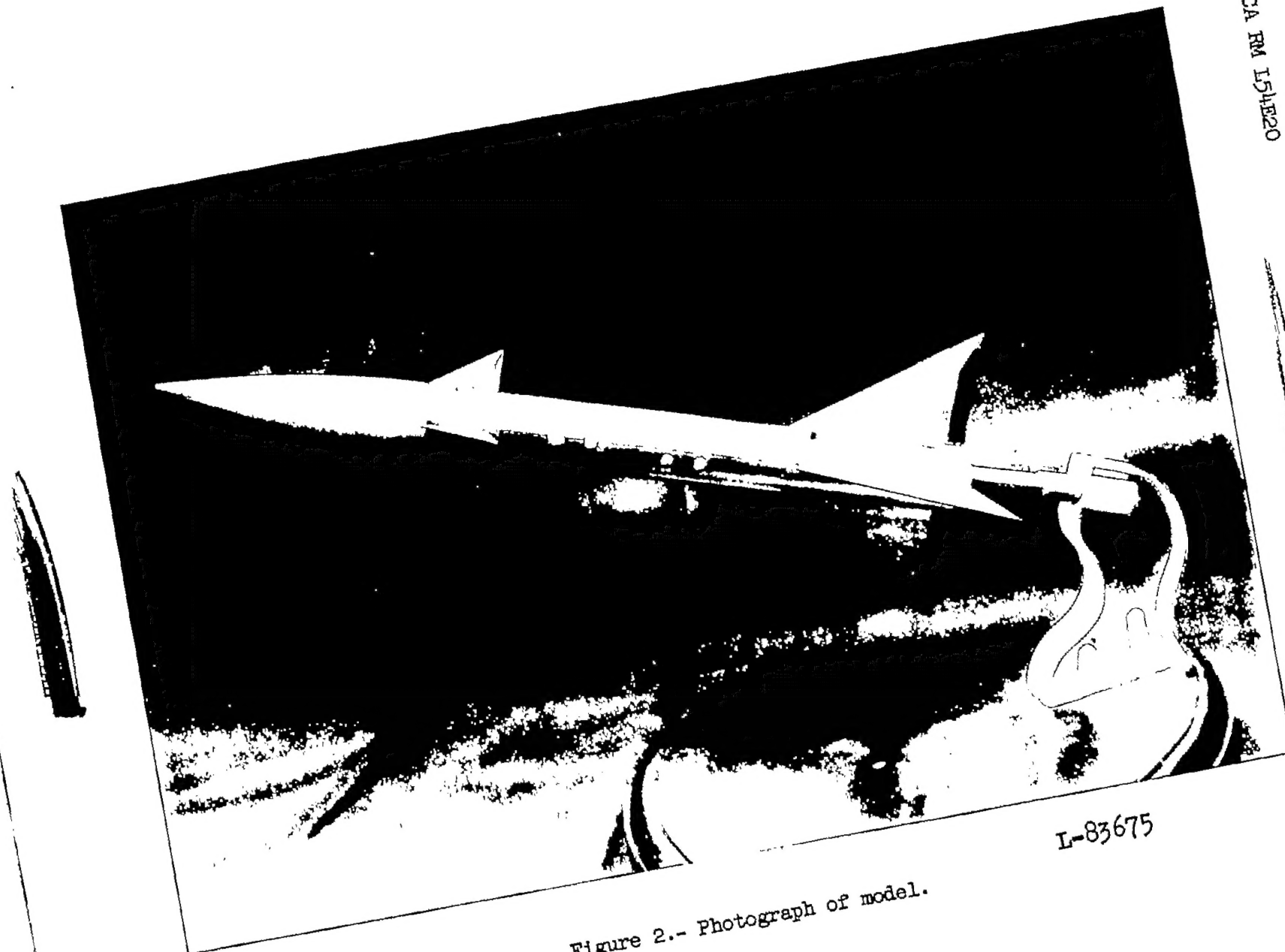


Figure 2.- Photograph of model.

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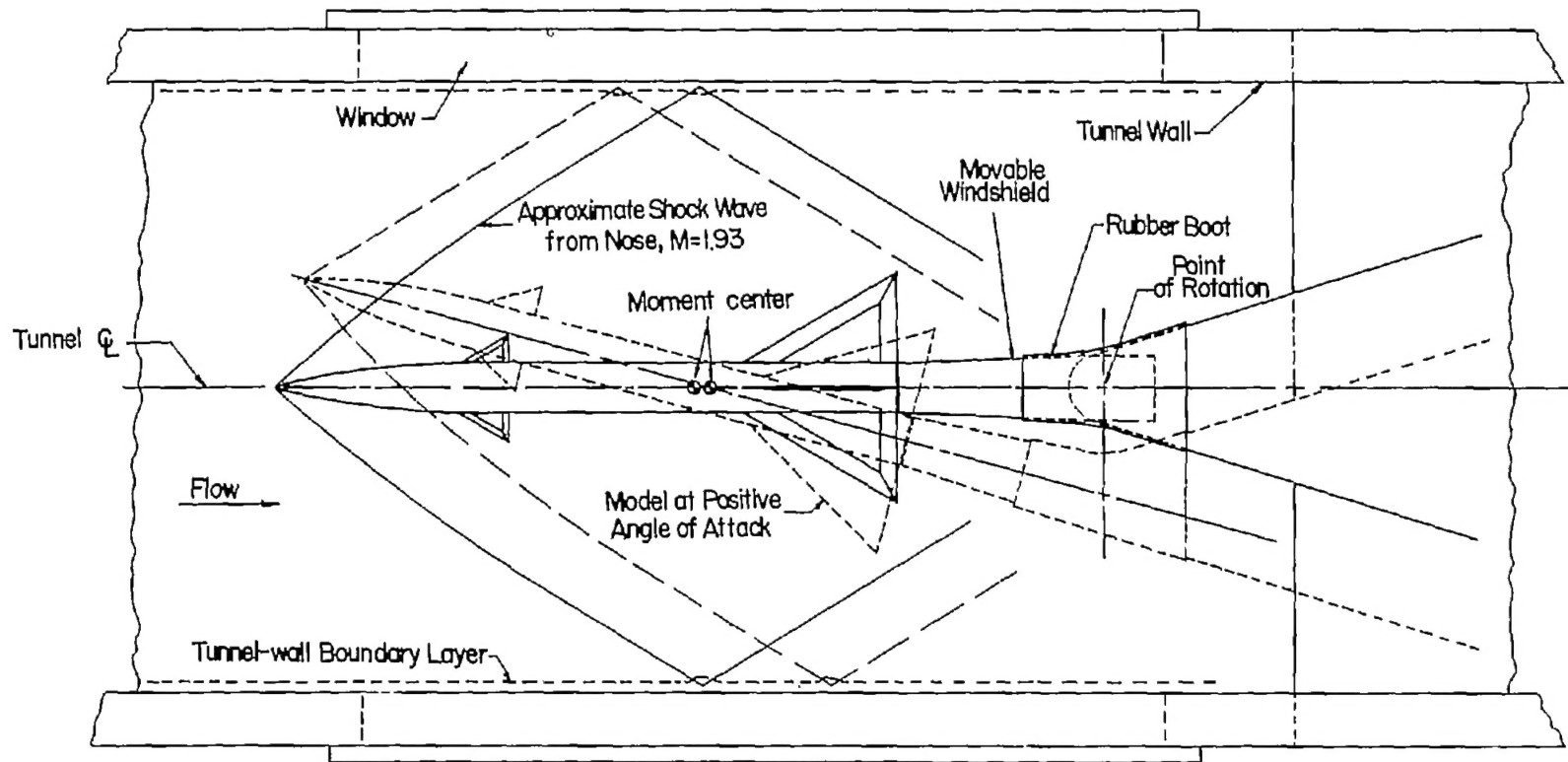


Figure 3.- Model installation in tunnel.

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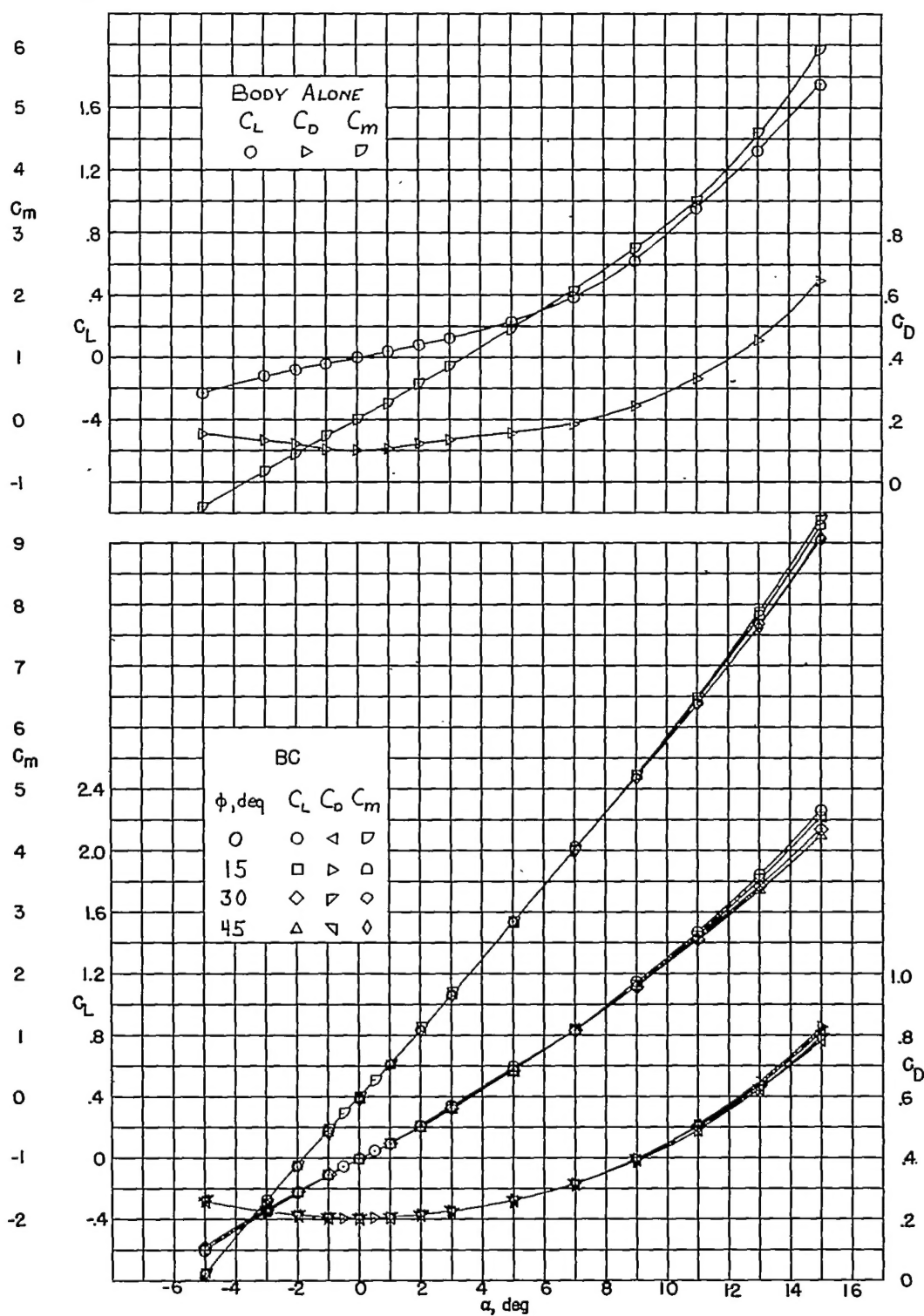


Figure 4.- Aerodynamic characteristics of B and BC configurations for various angles of roll.  $M = 1.62$ ;  $\delta_e = \delta_r = 0^\circ$ .

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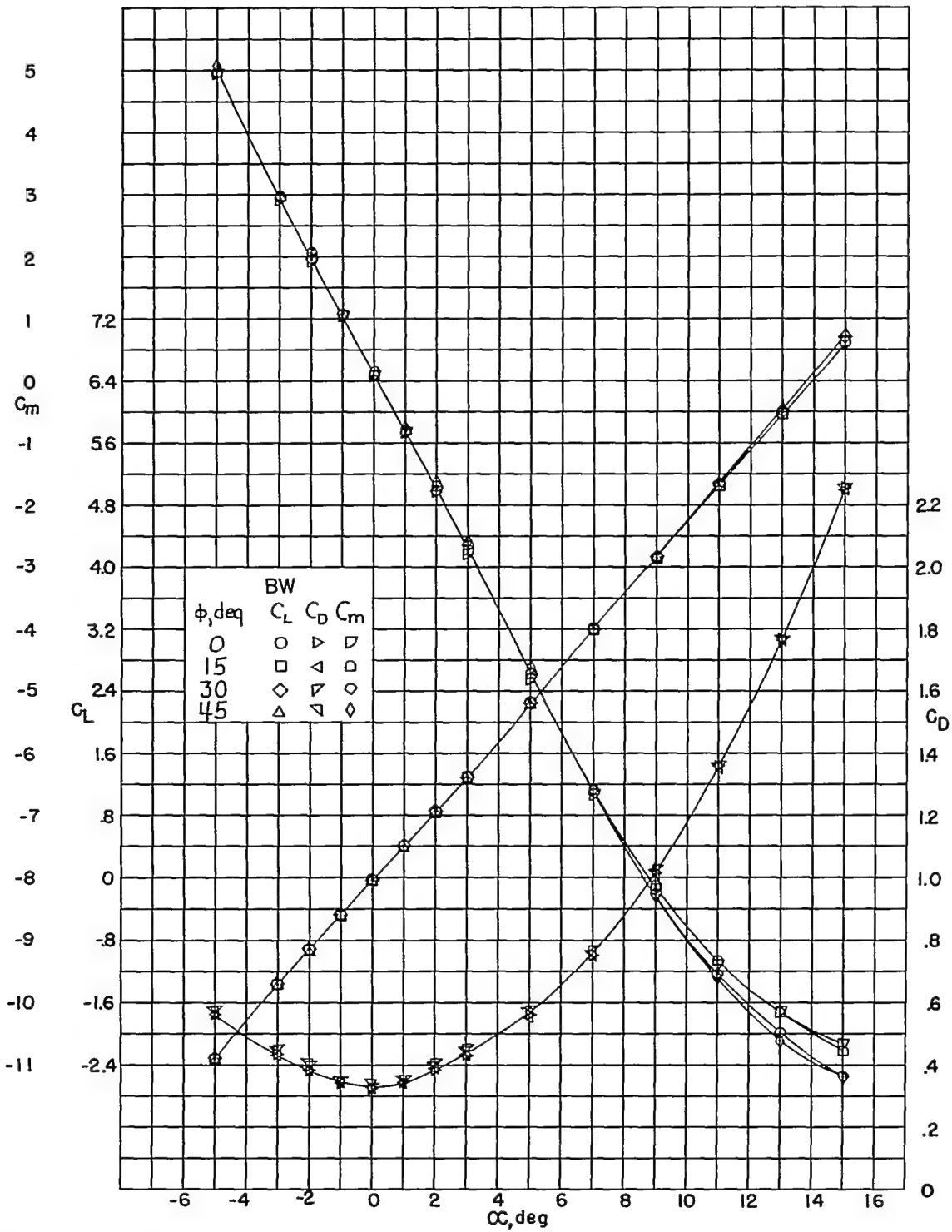


Figure 5.- Aerodynamic characteristics of BW configuration for various angles of roll.  $M = 1.62$ .

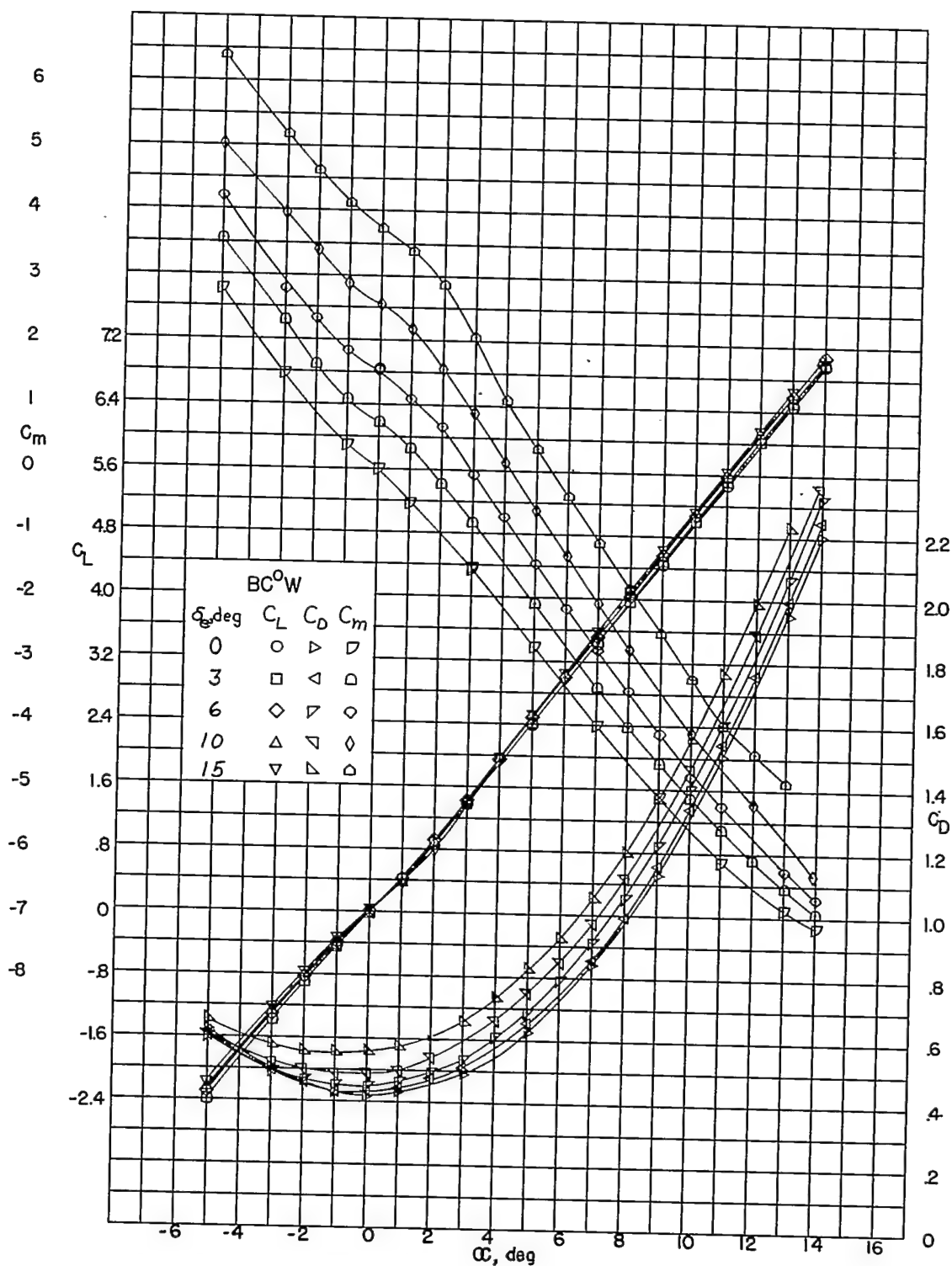


Figure 6.- Aerodynamic characteristics of inline BCW configuration for various deflections of the pitch canard fins.  $M = 1.62$ ;  $\delta_r = \phi = 0^\circ$ .

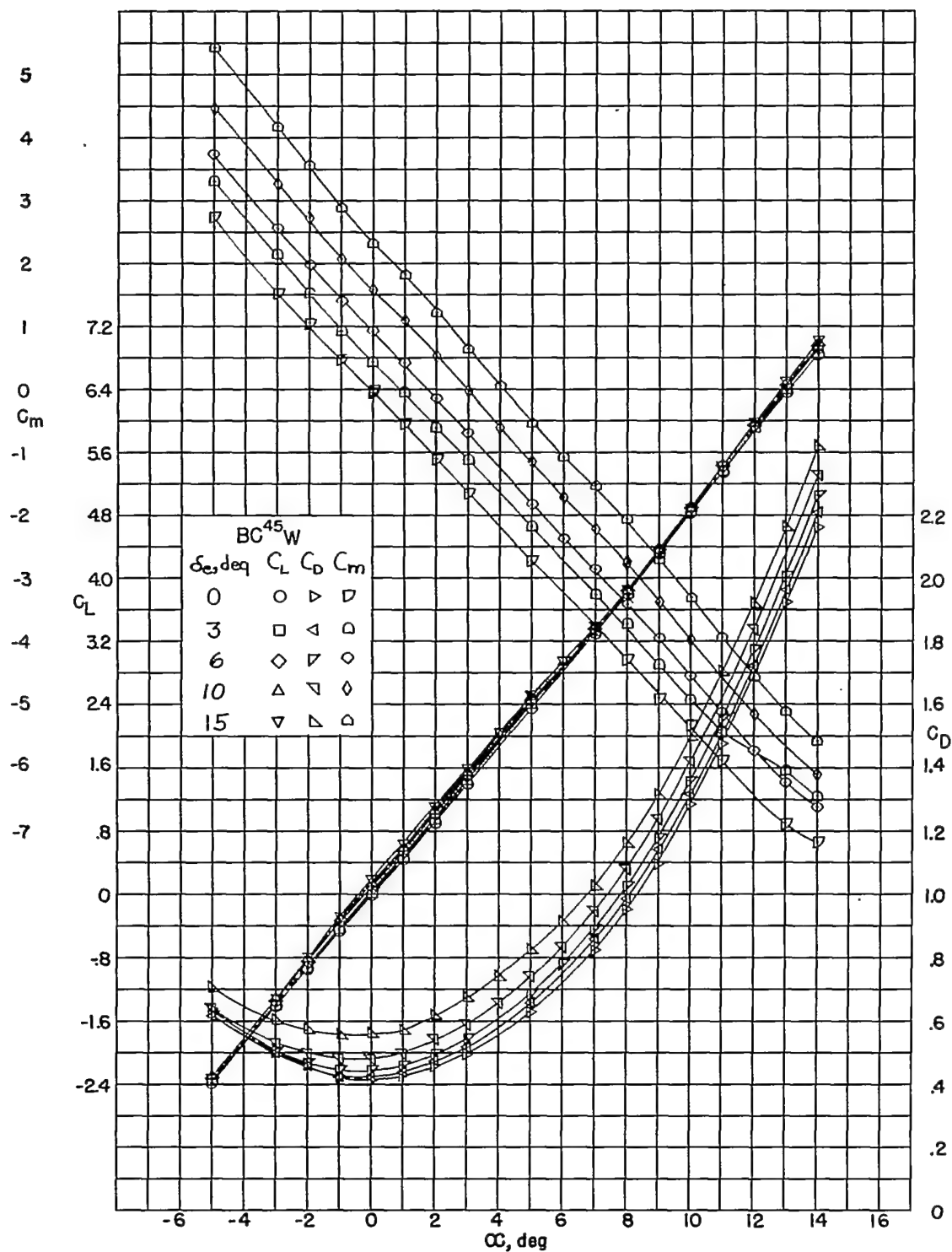


Figure 7.- Aerodynamic characteristics of interdigitated BCW configuration for various deflections of the pitch canard fins.  $M = 1.62$ ;  $\delta_r = \phi = 0^\circ$ .

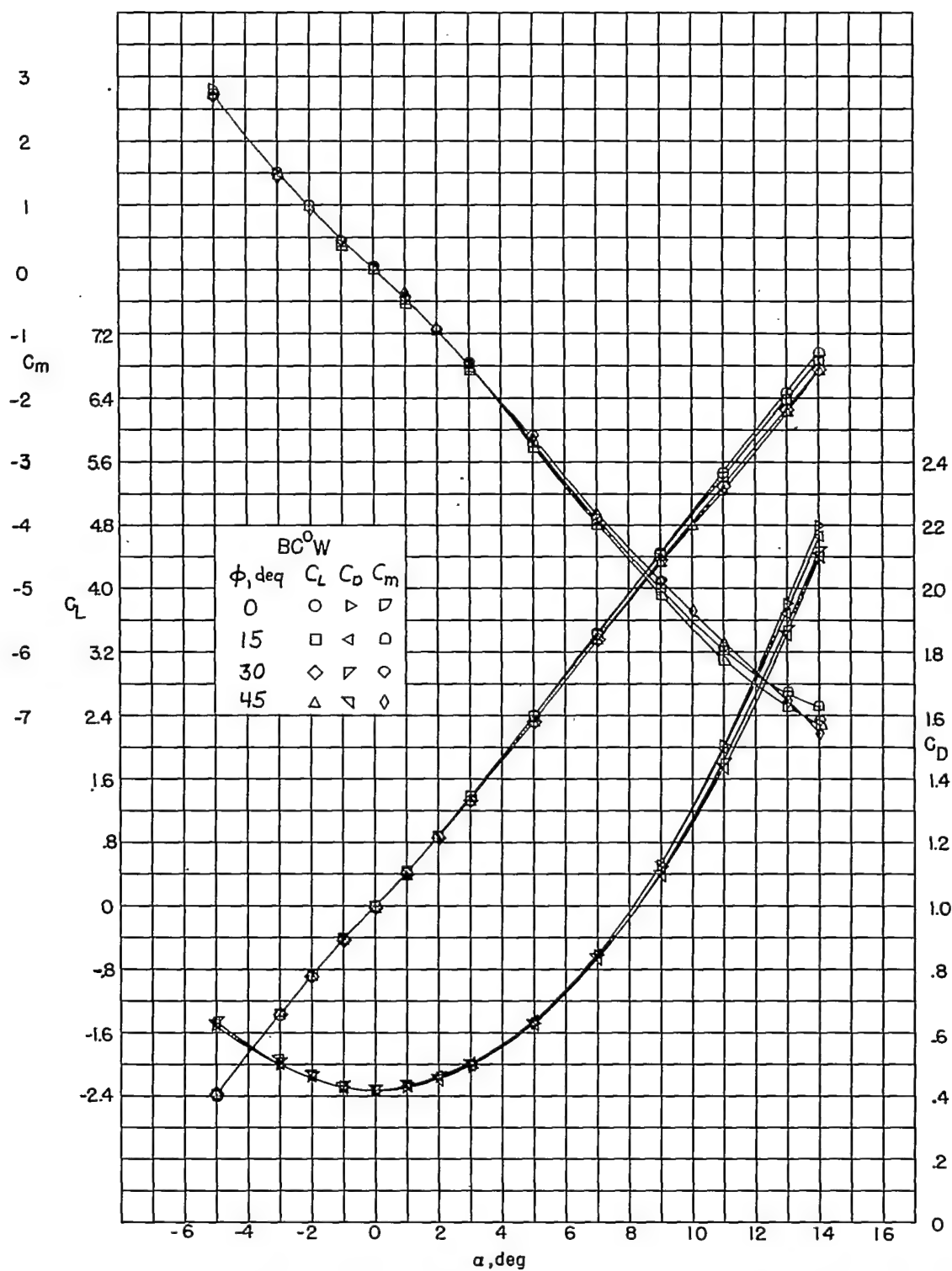


Figure 8.- Aerodynamic characteristics of inline BCW configuration for various angles of roll.  $M = 1.62$ ;  $\delta_e = \delta_r = 0^\circ$ .

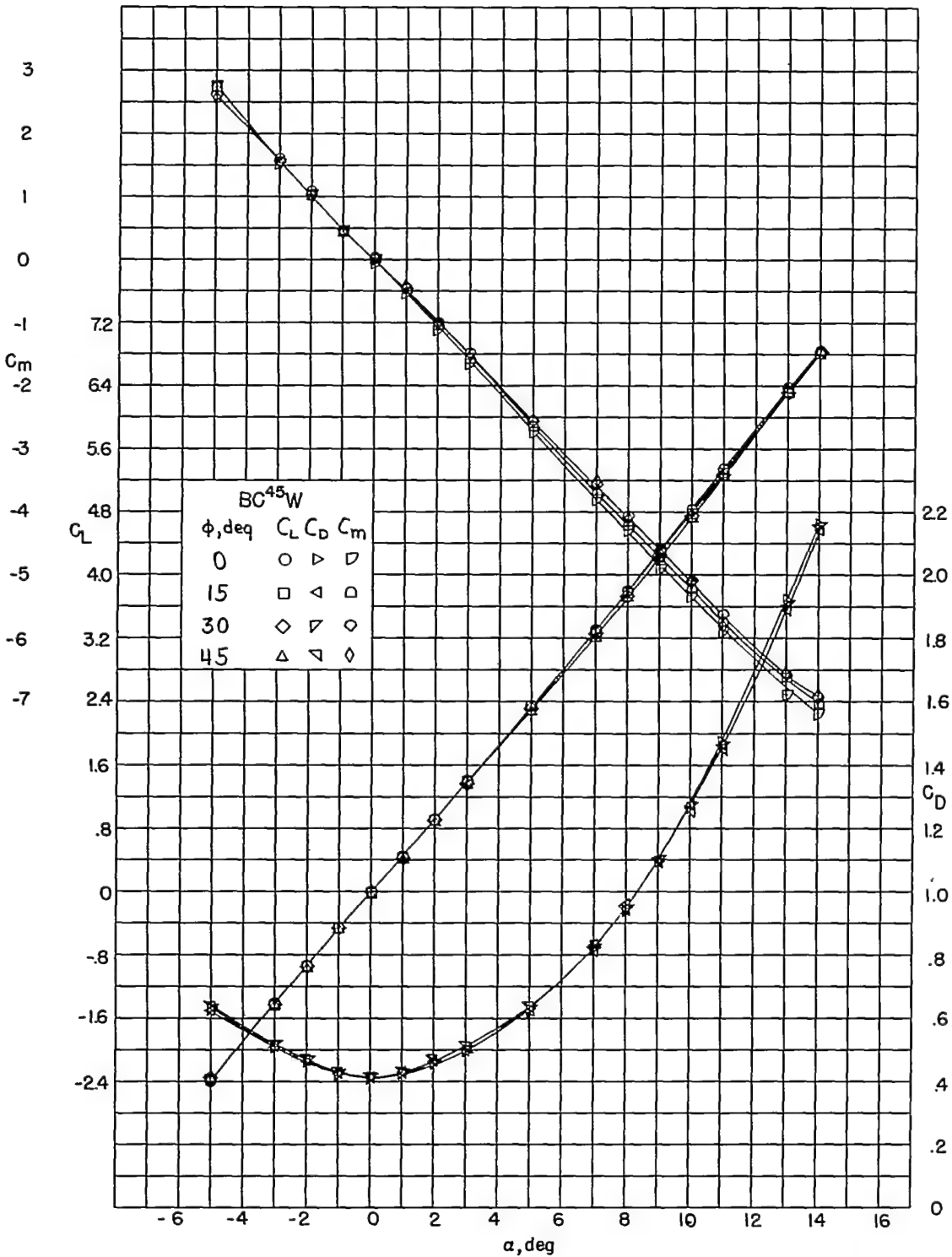


Figure 9.- Aerodynamic characteristics of interdigitated BCW configuration for various angles of roll.  $M = 1.62$ ;  $\delta_e = \delta_r = 0^\circ$ .

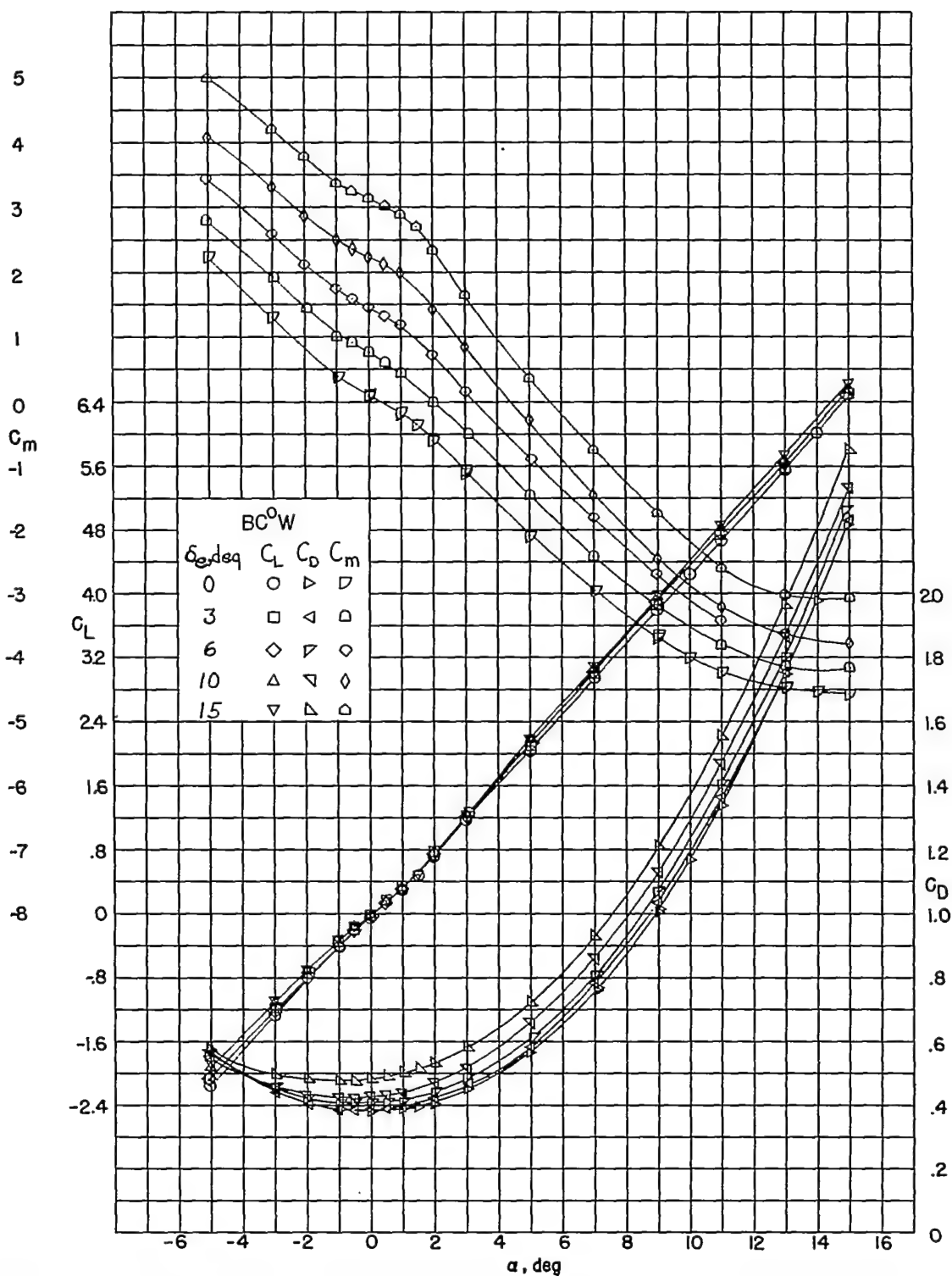


Figure 10.- Aerodynamic characteristics of inline BCW configuration for various deflections of the pitch canard fins.  $M = 1.93$ ;  $\delta_r = \phi = 0^\circ$ .



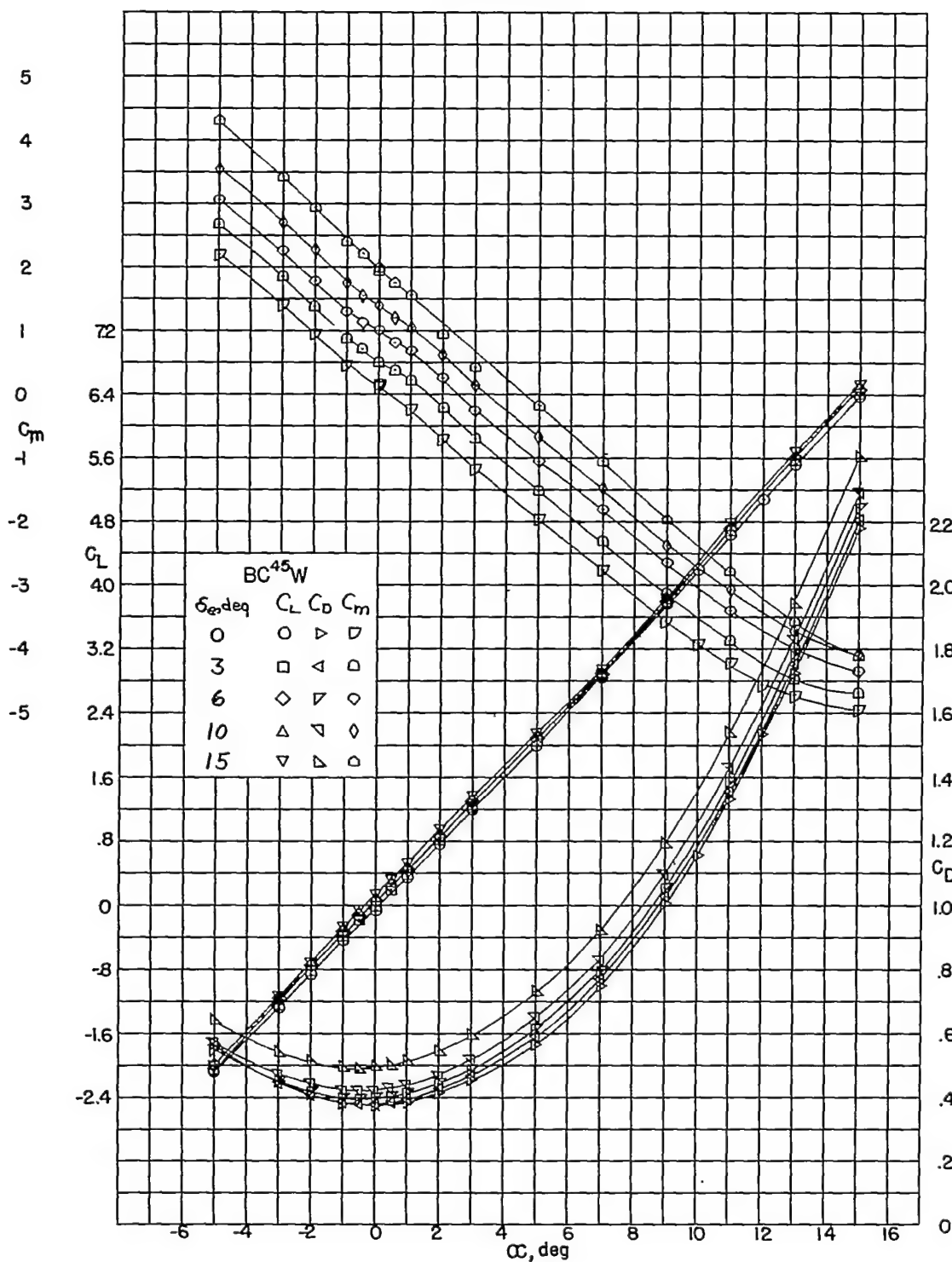


Figure 11.- Aerodynamic characteristics of interdigitated BCW configuration for various deflections of the pitch canard fins.  $M = 1.93$ ;  $\delta_r = \phi = 0^\circ$ .

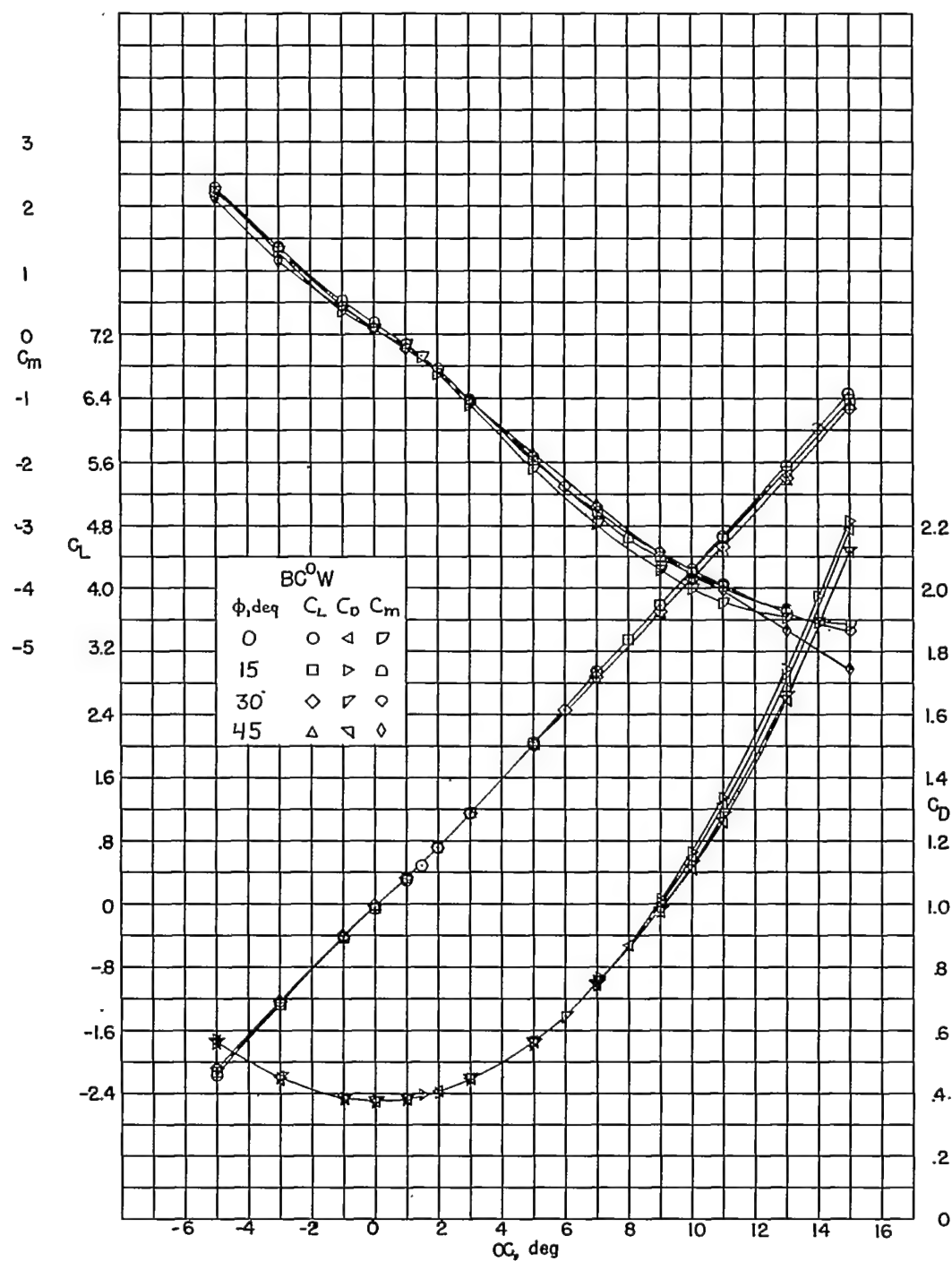
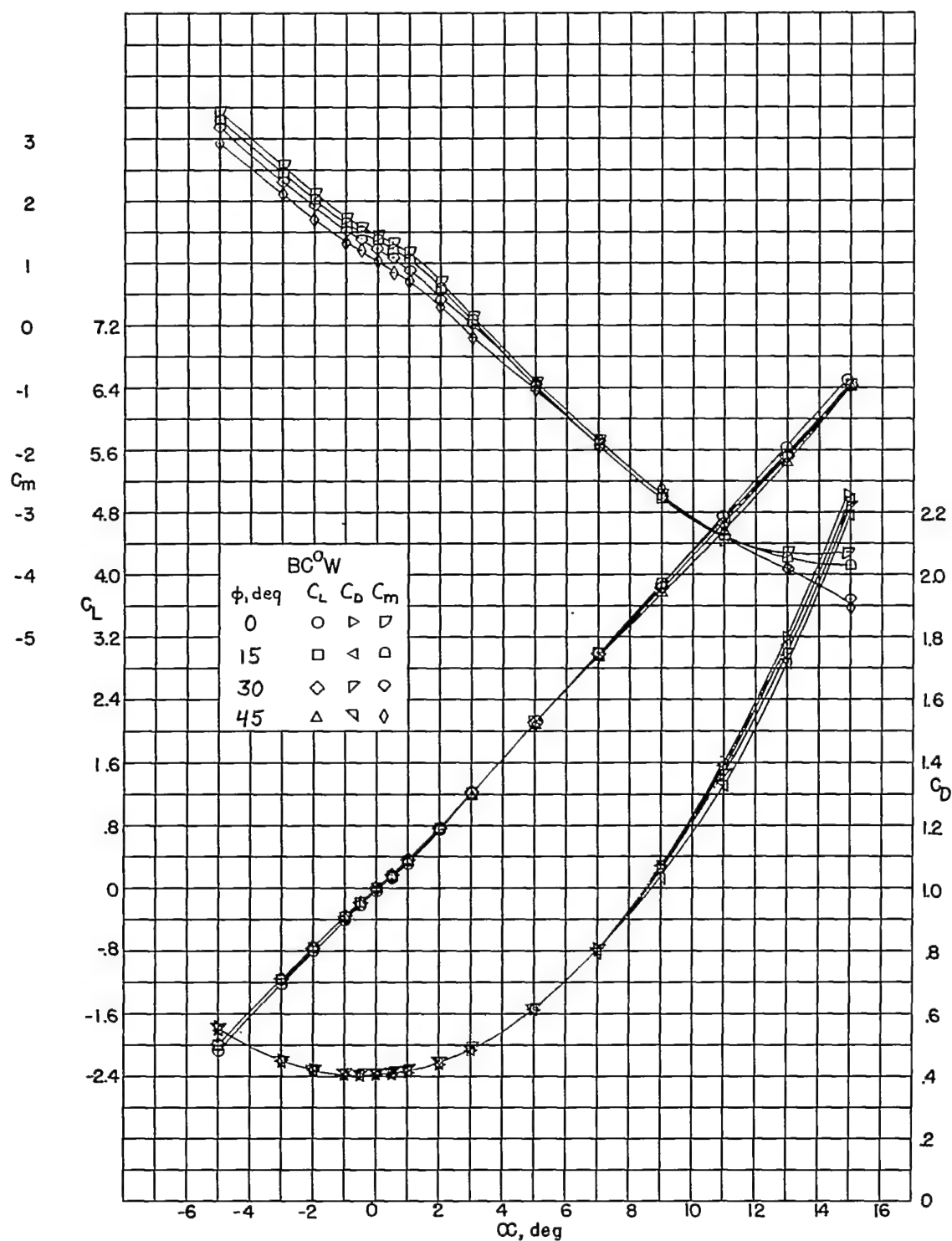
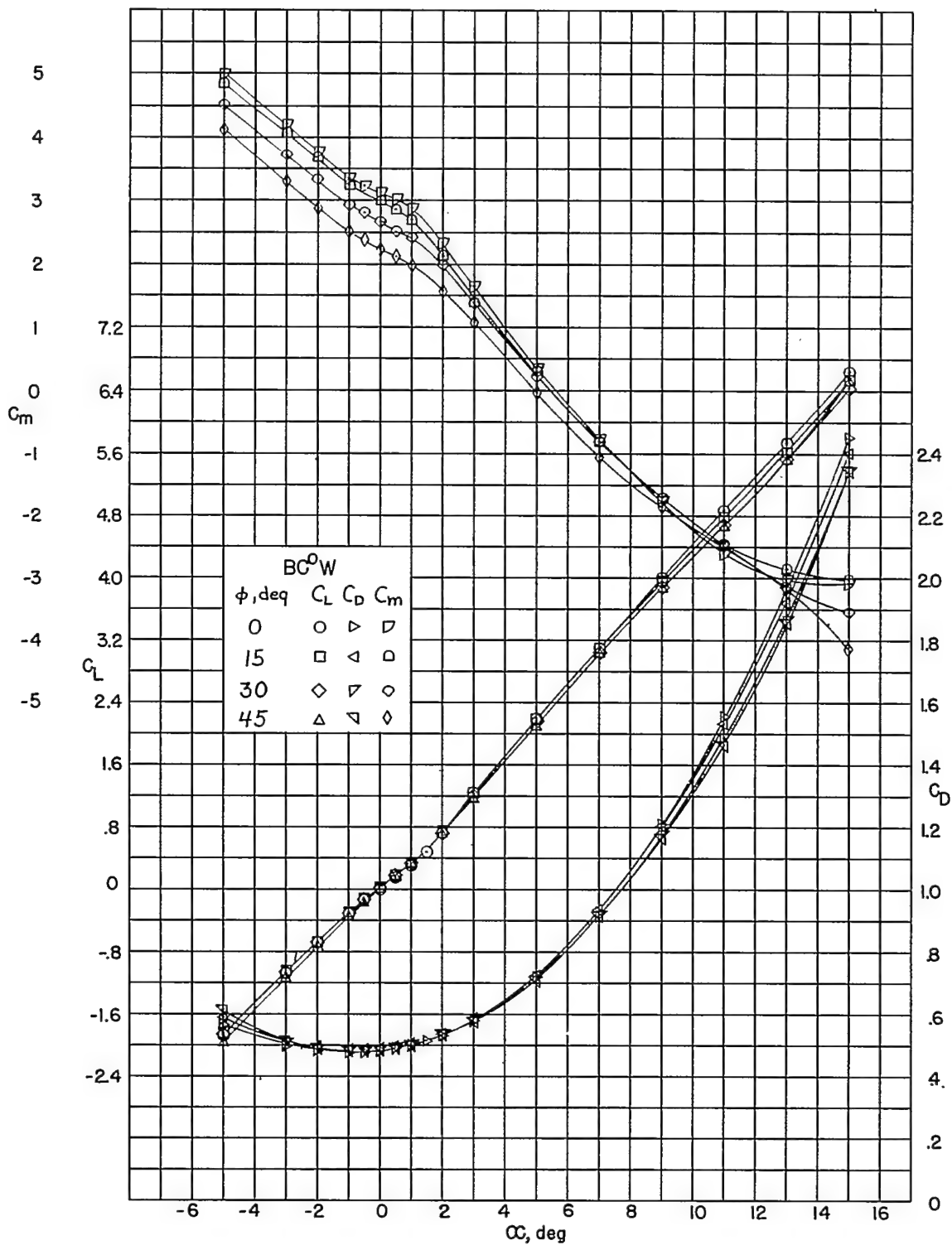
(a)  $\delta_e = 0^\circ$ .

Figure 12.- Aerodynamic characteristics of inline BCW configuration for various angles of roll with fixed deflections of the pitch canard fins.  $M = 1.93$ ;  $\delta_r = 0^\circ$ .



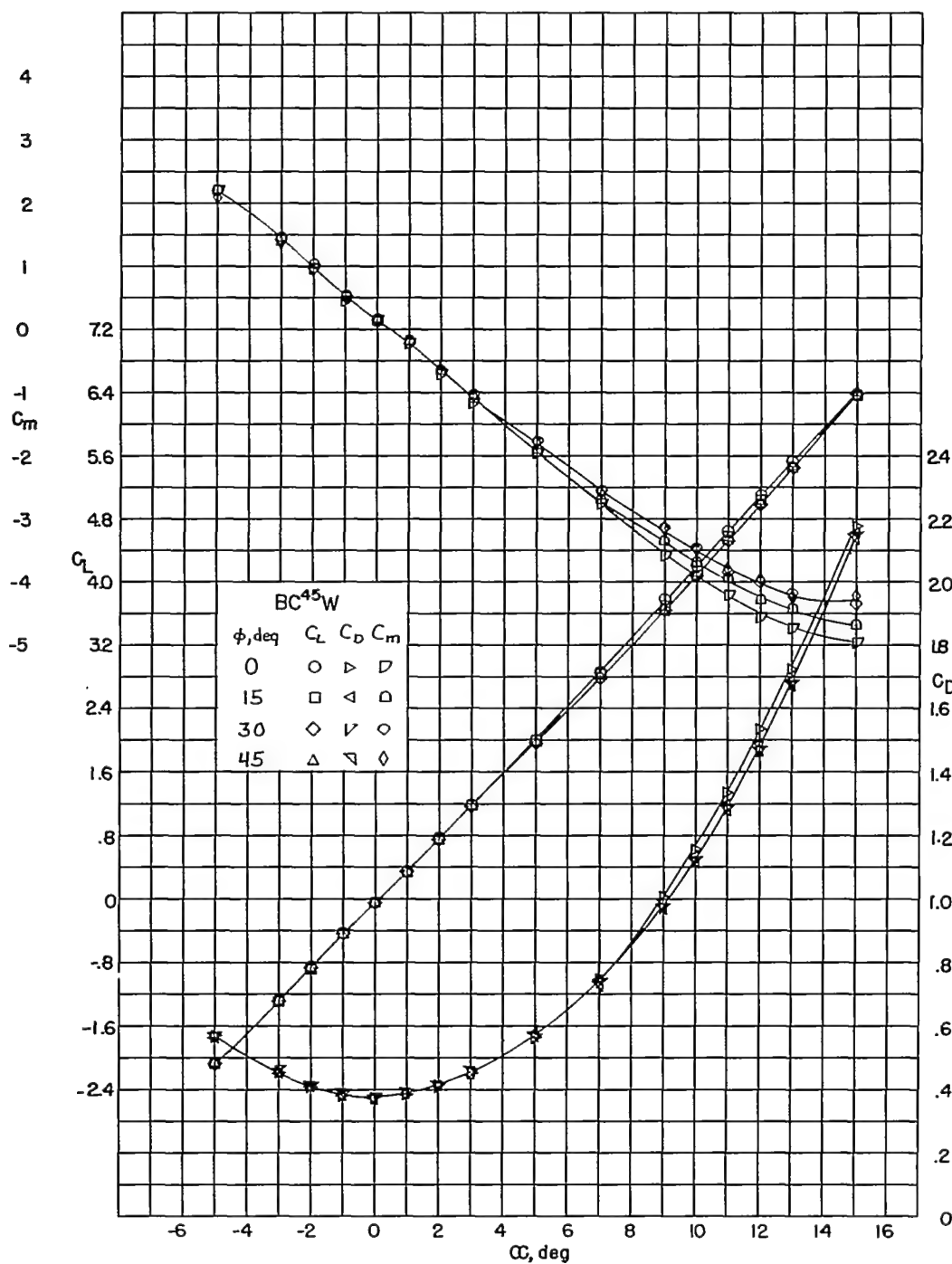
(b)  $\delta_e = 6^\circ$ .

Figure 12.- Continued.



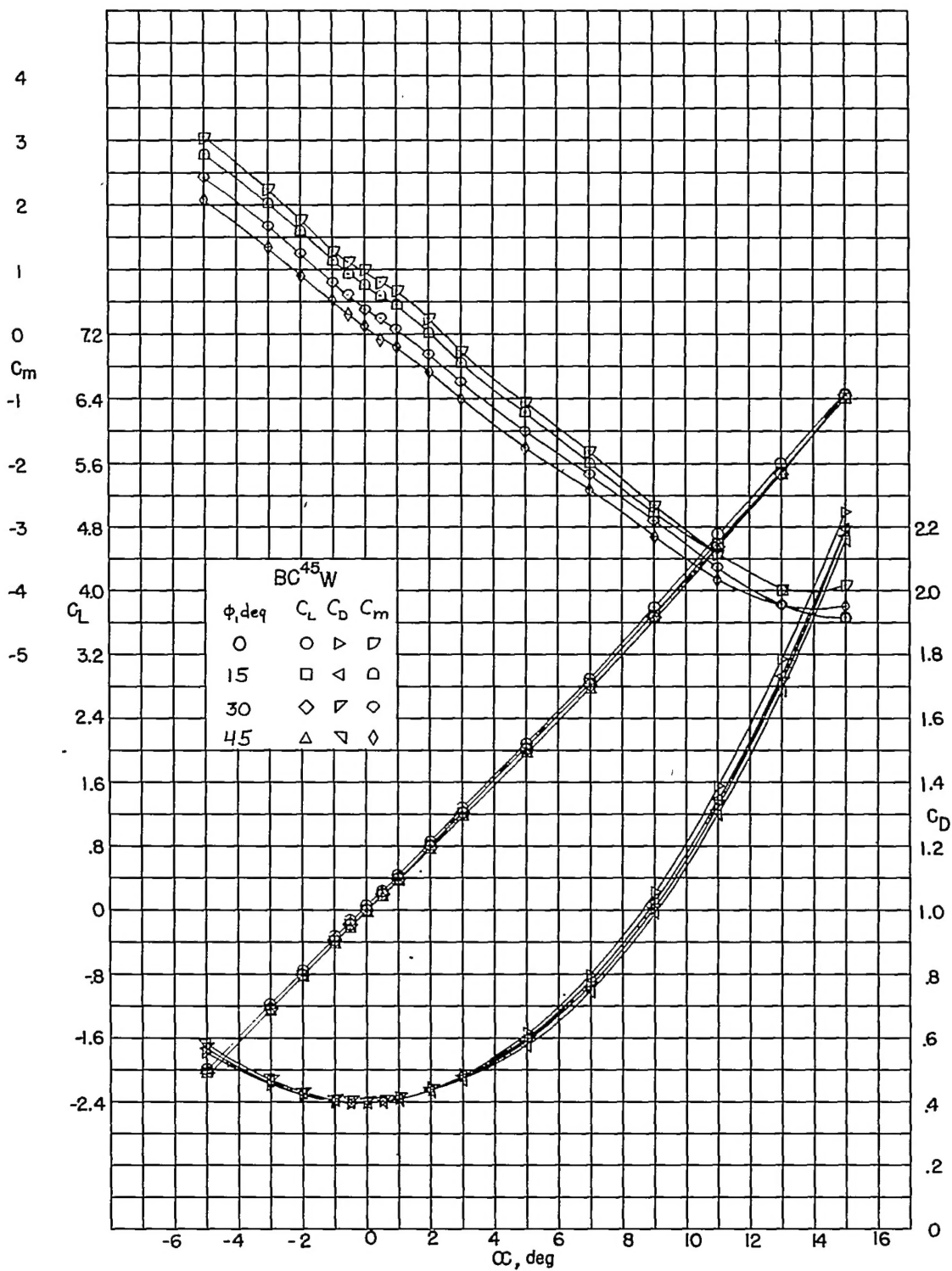
(c)  $\delta_e = 15^\circ$ .

Figure 12.- Concluded.



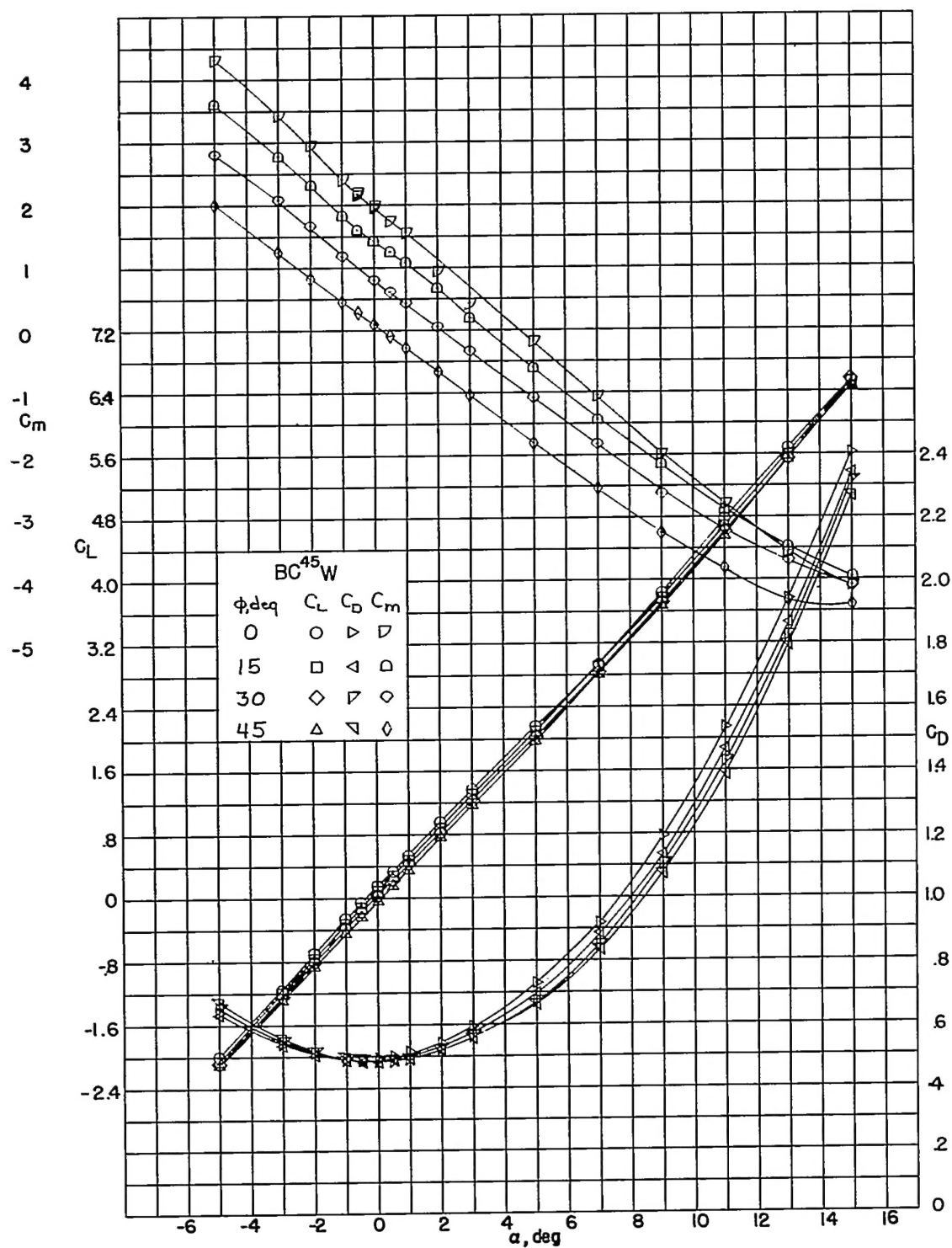
(a)  $\delta_e = 0^\circ$ .

Figure 13.- Aerodynamic characteristics of interdigitated BCW configuration for various angles of roll with fixed deflections of the pitch canard fins.  $M = 1.93$ ;  $\delta_r = 0^\circ$ .



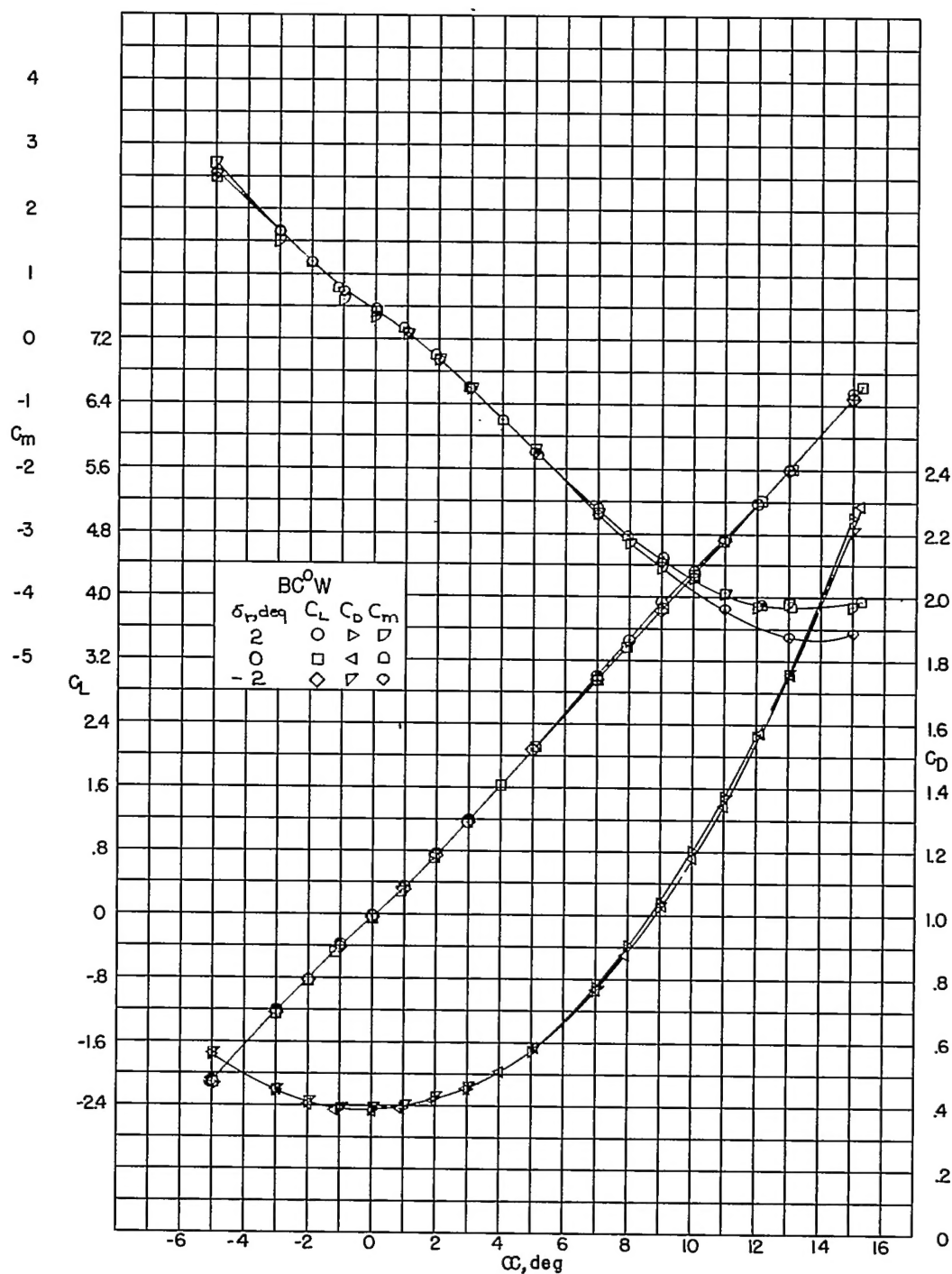
(b)  $\delta_e = 6^\circ$ .

Figure 13.- Continued.



(c)  $\delta_e = 15^\circ$ .

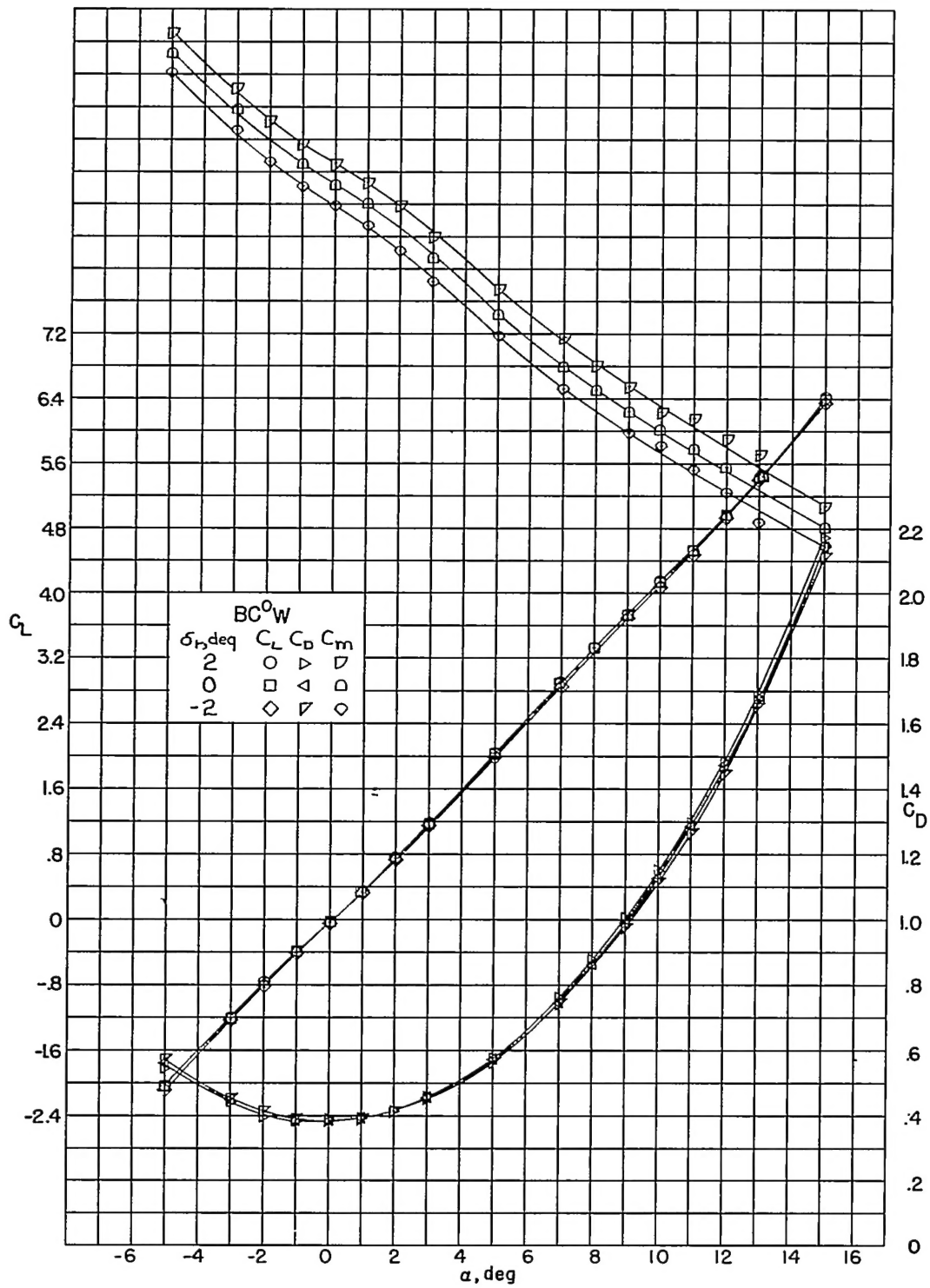
Figure 13.- Concluded.



(a)  $\phi = 0^\circ$ .

Figure 14.- Aerodynamic characteristics of inline BCW configuration for combined deflections of the pitch and yaw canard fins.  $M = 1.93$ ;  $\delta_e = 1^\circ$ .





(b)  $\phi = 45^\circ$ .

Figure 14.- Concluded.